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EVALUATION OF THE AVIATION WEATHER AND NOTAM SYSTEM (AWANS)

Hugh D. Milligan

Bruce L. Rosenberg

JUNE 1979

FINAL REPORT

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

NOTICE

Technical Report Documentation Page

18 19

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-RD-79-46	AD-A086 167	

4. Title and Subtitle	5. Report Date
6 EVALUATION OF THE AVIATION WEATHER AND NOTAM SYSTEM (AWANS)	11 June[redacted]79
	6. Performing Organization Code
7. Author(s) 10 Hugh D. Milligan, Bruce L. Rosenberg	8. Performing Organization Report No. 14 FAA-NA-79-13
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Federal Aviation Administration National Aviation Facilities Experimental Center Atlantic City, New Jersey 08405	11. Contract or Grant No. 132-403-511
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Systems Research and Development Service Washington, D.C. 20590	9 Final rept. Aug[redacted]75-Sep[redacted]976
	14. Sponsoring Agency Code

15. Supplementary Notes

12 51

16. Abstract

This activity was conducted to ascertain the operational effectiveness of an experimental system in providing automation capabilities geared to flight service station application. Primary consideration was given to the man-machine relationship and the efficacy of the data and presentation formats made available to the specialist through the system. Maintenance, technical, and software aspects were not specifically addressed.

Results of the study indicate that the automated system provides textual and graphic data in a form suitable for use in preflight and in-flight briefing modes. Further, the equipment configurations under study contained one which was acceptable, though not deemed optimal, by the specialists. This acceptability included the display size, character size and font, graphic and textual products, communications equipment, console design, and associated equipment layout.

17. Key Words	18. Distribution Statement
Air Traffic Control Flight Service Stations Aviation Weather NOTAM System	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	50	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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METRIC CONVERSION FACTORS

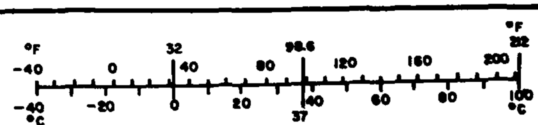
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

The purpose of this effort was to conduct an operational evaluation of the Aviation Weather and NOTAM System (AWANS) in the Atlanta, Georgia, Flight Service Station (FSS). Specifically, the areas of interest were those aspects of the system which (1) had a pronounced impact on the delivery of essential weather and Notice to Airmen (NOTAM) information to pilots via radio or telephone, in terms of time expended and quality of content, (2) had a measureable effect on the FSS specialist with regard to how well the specialist could use the system and how well the system responded to an expressed need, and (3) provided sufficient indicia of the feasibility of using an automated system for the acquisition and dissemination of aviation weather, flight plan, NOTAM's and flight assistance services information.

BACKGROUND.

Over the past few years, there has been a marked increase in the demand for FSS services. All indications are that this trend will continue in the forseeable future. It was quite apparent to the Federal Aviation Administration (FAA) that the application of contemporary technology to the problem was required if the increased demand was to be met at reasonable cost. A decision was made to conceive, design, procure, install, and evaluate an automated FSS system. To that end, in mid-1972, a contract was let to E-Systems Inc. of Garland, Texas, for the production of such a system. Subsequent action resulted in the installation of the system in the Atlanta, Georgia, FSS, located at Charlie Brown County Airport, Atlanta, Georgia. National Aviation Facilities Experimental Center (NAFEC) was assigned the task of conducting a comprehensive operational test and evaluation of the system to determine the effectiveness of the concepts embodied in the original design and to make recommendations for modifications if required.

DISCUSSION

In general, the introduction of automation into any function which previously encompassed only manual activity is bound to have a profound effect on operational philosophy and personnel. This was no less true in the case of AWANS. Consequently, it became the responsibility of NAFEC to devise a test plan which would address (1) the impact of an automated system on the FSS specialist, (2) the operational efficacy of the system being scrutinized, and (3) the interaction between the newly installed system and components of the existing system.

AWANS DATA COLLECTION PLAN.

The AWANS software package provided for the collection of data concerning areas of administrative concern. This capability was insufficient to fulfill the needs of a strenuous test and evaluation (T&E) effort. Therefore, NAFEC devised a data collection package designed to satisfy those concerns of interest incident to T&E activity. It was not possible to economically effect an automated data collection system which would have mandated extensive

AWANS software modification. Described below in brief is a sketch of the NAFEC manual data collection scheme.

Three types of data were collected: (1) objective measures, (2) subjective measures, and (3) environmental measures. The bulk of objective measures were collected on the preflight briefing positions. Some of these measures were; time spent on the briefing, number of pages accessed per briefing, and class of data called-up (flight plan format, weather text, maps or radar, and/or other printed reference material). These data were categorized by console configuration, group display status, type of flight plan, type of transaction (weather briefing only, flight plan filing only, and weather briefing and flight plan filing combined), and local weather conditions. This classification, along with counts of the transactions falling in the classes, provided a valuable statistical profile of the AWANS operation. Task analyses (timing and task count) were performed on the in-flight briefing position and the system data coordinator position. Hourly system communications loadings were determined for a period of a week. The time delay between the keying of a function and the first appearance on the display, and the page-writing times, were measured for 15 different system functions.

The subjective measures were in the form of three Specialist Opinion Surveys (SOS I, II, and III) and a System Improvement Report (SIR). SOS I treated general aspects of AWANS; whereas, SOS II treated specific aspects of the operation and design. Both were administered during August, October, and December 1975 and July 1976. SOS III solicited specialist preferences for 21 possible console and group display configurations. The SIR was a mostly blank sheet on which suggestions could be submitted.

Environmental factors including lighting levels, noise levels, subtended visual angles of the displays were measured. A photographic survey of the AWANS equipment, consoles, and workspace arrangement was conducted.

The wide range of measures taken permitted a detailed characterization of the operation of AWANS, indicated what the specialists think about it, and pointed the way to improvements for follow-on systems.

SYSTEM POSITIONAL AND HARDWARE DESCRIPTION.

The AWANS equipment consisted of three basic subsystems; the central computer complex, the local display subsystem, and the remote display subsystem. The system was interfaced with five data sources and was under the control of the central computer complex. The five data sources were: (1) the Weather Message Switching Center (WMSC) located at Kansas City, Missouri, to provide Service-A weather data, (2) the Automated Service-B Distribution System (A-BIS) network (via an Aeronautical Fixed Telecommunications Network (AFTN) interface) for transmission and receipt of Service-B flight-oriented data, (3) the National Weather Service (NWS) WBRR-68 slow-scan radar remoting system to provide weather radar displays, (4) the NWS digital facsimile network for display of NWS-generated weather maps and, (5) a graphics tablet for generating graphic displays within the local AWANS facility.

The initial installation of the central computer complex consisted of

two Tempo II general purpose minicomputers, each with 64K words of 16-bit core memory. Additionally there was an ASR 33 console teletype for each processor, a medium-speed line printer, a card reader, and two magnetic tape units. One processor was dedicated to communications tasks with external lines, while the other was tasked with data manipulation and request processing. Each processor operated independently, but communication was through computer interfaces using direct memory access. Associated with the processors were synchronous modem multiplexers, an asynchronous modem controller, graphics and alphanumeric drivers, video generators, refresh memories, an automatic dialing unit for remote weather (WX) radar, and disk controllers. Six dual recording disks were installed with the system. A third processor with 8K words of core memory was installed at the NWS office at Atlanta Hartsfield Airport to store and display graphic products forwarded from the Atlanta FSS.

The Atlanta FSS display system consisted of all specialists positions with associated keyboards, cathode-ray tube (CRT) displays, and two groups of five each 23-inch CRT displays which were considered common displays for everyone's viewing.

The remote system consisted of all other operator terminals functioning via polled dedicated telephone circuits connected to the host computer at the Atlanta FSS. Initially, the intended locations for these equipments were the following: (1) FAA Headquarters, Washington, D.C.; (2) the Atlanta NWS Forecast Office; (3) Macon, Georgia, FSS; and, (4) a fixed-base operator (FBO) at the Atlanta Hartsfield Airport. The terminal destined for the fixed-base operator was not installed, and further changes were made to both the local and remote display configurations. Table 1 depicts the initial installation and the current installation.

Since the advent of the initial system configuration, several major system changes have evolved, including the elimination of the remote graphics processor for NWS and the procurement of a third processor for system redundancy, training, and offline processing of statistical reports. Installed with the third processor was a disk controller and two additional disk units. Another change was the replacement of the "Printec" impact printers supplied in the initial system with "Scope Data" electrostatic printers for noise reduction and reduced maintenance. These subsystems, together with the control computer complex, constituted the Atlanta FSS AWANS.

A layout of the operational positions within the Alanta FSS is shown in figure 1.

OPERATIONAL AND FUNCTIONAL DESCRIPTION.

Automation of the FSS function is the primary purpose of AWANS. To that end AWANS automated four primary operational functions: (1) the storage and retrieval of weather data (2) the storage and display of graphic weather information, (3) the handling of flight data and, (4) the support of routine, miscellaneous administrative tasks normally performed in an FSS.

The AWANS weather data base is received from WMSC via a 2,400-baud synchronous digital communications line. The weather data supplied to the AWANS system consisted of all weather reports from the continental United States plus selected reports from Canada, Mexico, Puerto Rico, the

TABLE 1. INITAL AND CURRENT INSTALLATION

SYSTEM CONFIGURATION

Initial Installation At Atlanta FSS

16 positions of operation:
- 2 single positions (alphanumerics (A/N) only)
- 1 dual position (1 A/N + 1 graphics)
- 2 shared positions (2 A/N + 1 graphics)
- 11 single positions (A/N + graphics combined)

11 23-inch group CRT monitors (graphics only)

Initial Installation At Macon, Georgia, FSS

3 single positions (A/N only)

Current Installation At Atlanta FSS

16 positions of operations (same as initial installation)
16 23-inch group CRT monitors (14 graphics only + 2 coincident with training terminal)

Current Installation At Macon FSS

4 single positions (A/N only)

OPERATIONAL POSITION DISTRIBUTION

Initial Installation

Terminal

8	Preflight
1	Assistant Chief
2	System Data Coordinator (SDC)
2	In-flight
1	Enroute Flight Advisory Service (EFAS)
1	Training
1	Face-to-Face Briefing

Group Displays

10	Preflight (2 sets of 5 each)
1	In-flight

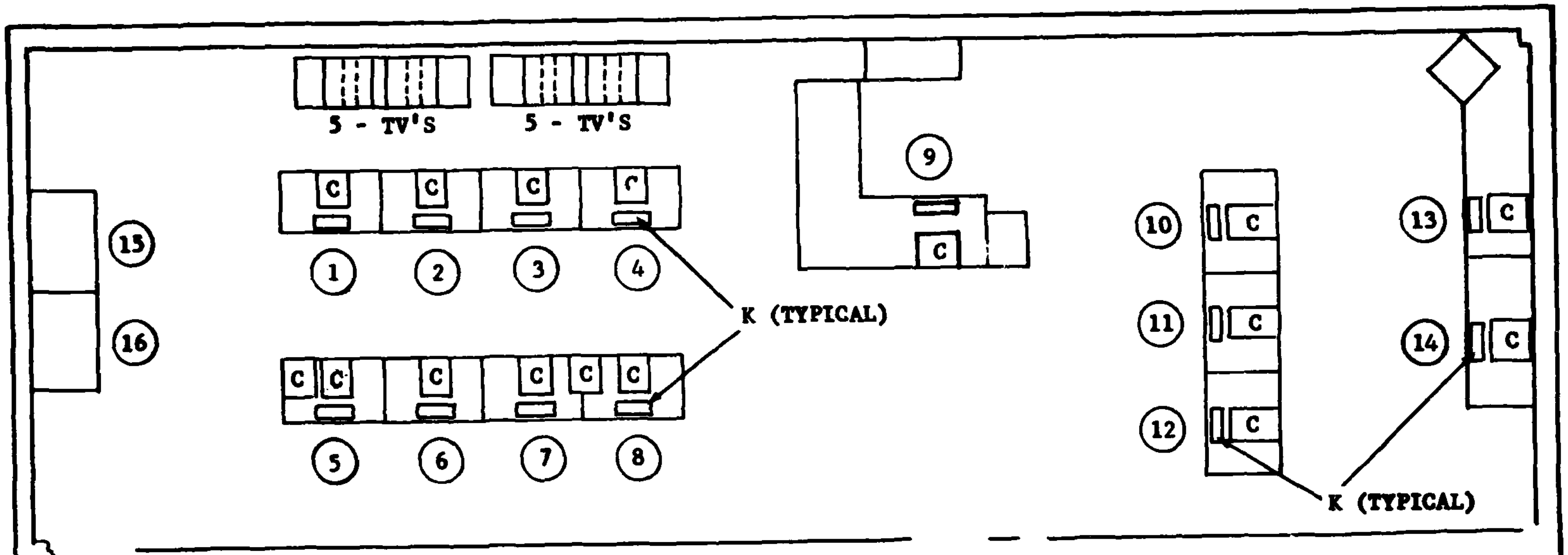
Current Installation

Terminal

8	Preflight
1	Assistant Chief
2	System Data Coordinator (SDC)
1	SDC, fast-file and general duties
1	In-flight
1	Enroute Flight Advisory Service
1	Training
1	Face-to-Face Briefing
1	DSS/AF Staff (Remote-Type Terminal)

Group Displays

10	Preflight (2 sets of 5 each)
1	In-flight
3	EFAS
2	Training



PREFLIGHT	POSITIONS AS INDICATED
1,2,3,4,6	ONE TERMINAL DISPLAYING BOTH TEXT AND GRAPHIC WEATHER INFORMATION
5	TWO TERMINALS: THE RIGHT DISPLAYS GRAPHICS AND TEXT, THE LEFT DISPLAYS TEXT ONLY
7,8	TEXT AND GRAPHIC WEATHER ON POSITION TERMINALS WITH A SHARED "GRAPHICS ONLY" TERMINAL LOCATED BETWEEN THE TWO
9	ASSISTANT CHIEF,ONE TERMINAL DISPLAYING BOTH TEXT & GRAPHIC WEATHER INFORMATION
10,11,12,	SYSTEM DATA COORDINATOR
13	IN-FLIGHT
14	ENROUTE FLIGHT ADVISORY SERVICE
15	PATWAS/TWEB
16	GRAPHIC TABLET FOR LOCALLY GENERATED GRAPHICS
TV	23 INCH GROUP TV MONITORS
C	CRT
K	KEYBOARD

79-13-1

FIGURE 1. AWANS OPERATIONAL POSITION LAYOUT

Caribbean and the Bahamas. The system was designed to automatically file the weather data based on location and report type. Weather reports which were garbled or could not be handled by the automated system were sent to the System Data Coodinator position for identification and handling. The types of weather reports and flight-related information handled were the following:

1. Severe Weather Outlook Narrative (AC)

2. Flight Advisories—SIGMET and AIRMET (WS, WA)

3. Hurricane Advisory (WH)

4. Aviation Area Forecasts (FA)

5. Winds and Temperatures Aloft Forecast (FD1, FD2, FD3)

6. Aviation Terminal Forecasts (FT)

7. Hourly Aviation Weather (SA)

8. Radar Weather Reports (SD)

9. Supplementary Aviation Weather (SW)

10. Notices to Airmen (NOTAM/D, NOTAM/L, or National Flight Data Center (NFDC))

11. Central Flow Control Advisories

12. Transcribed Weather Broadcast Synopsis

13. Service Weather Forecasts, Bulletins, and Status Reports (WW)

14. Pilot Weather Reports (UA)

The WMSC interface is also used to enter reports including hourly aviation weather observations, special aviation weather reports, pilot weather reports (PIREP's) and NOTAM's into the WMSC data base.

Information retrieval by a specialist was obtained by entering a single point, several points, a state or a route between two or more points. The points on a route could be identified by a three-character location identifier, longitude/latitude, a Victor or Jet airway and an intersection, or a fixed very high frequency omnirange (VOR) radial/distance. However, any point specified had to be part of the standard predefined structure, or no weather could be retrieved. The system had considerable flexibility in the methods by which information could be retrieved. For instance, any of the major report types could be requested in any order by the specialist. The amount of weather data display could be varied incrementally about a single point or series of points up to 127 nautical miles (nmi). Along a route, weather could be requested in zones of 10, 25, or 50 nmi along either side of the route. The specialist could specify the type, amount, and order of presentation of data. The system would detect an entry containing an incorrect route or location identifier and would not provide retrieval of any weather for that entry. For these isolated instances, the specialist was required to correct the error or use an alternative method to identify the route. Virtually all weather data were displayed in the direction of the route from beginning to end. This was particularly beneficial for extended briefings to locations for which a specialist was not entirely familiar. This feature considerably reduced the geographical knowledge normally required in long-distance briefings.

The speed of retrieval, which will be covered in detail, for the local AWANS terminals was very rapid and allowed a specialist access to weather at rates much faster than that which one normally reads. The speed of the data line and the automated storage of weather provided the specialist with rapid access to the most current weather information available.

The automated filing of weather reports eliminated the requirement to collect, post, and distribute weather information from teletype and facsimile sources. This had a twofold impact on operations. First, a specialist had additional time to provide basic services rather than manipulating paper, and secondly, the specialist responds to requests from pilots or scans the weather data base when not occupied to become familiar with changes in the situation.

AWANS had three sources of graphic weather information: (1) A 4,800-baud dedicated circuit over which digitized charts were transmitted from the National Meteorological Center (NMC) located in Suitland, Maryland, (2) the NWS weather radar remoting system (WBRR-68) via a dedicated line to the Athens, Georgia, NWS office or via a dial-up capability to a number of NWS offices throughout the country, and (3) graphic entry by means of a digital graphics tablet upon which weather maps were traced by Atlanta FSS personnel and stored in the system. To facilitate ease of entry, two background maps were semipermanently stored and did not have to be retraced each time a new map was generated.

System capacity allowed for storage of 13 NWS digitized graphics, 10 locally generated graphics, and 5 radar images. Access to the graphics products could be accomplished from any position keyboard by depressing either of two keys, MAPS or RADAR, and an identification number.

The AWANS system was interfaced to the Service-B Data Interchange System (BDIS) via a 750-baud, full-duplex circuit. Subsequently, an interface to the A-BDIS in Kansas City, Missouri, through the AFTN was installed. This interface allowed the handling of Service-B traffic which generally consisted of flight movement and control messages. These duties were performed at the flight data or in AWANS terminology, the SDC position.

Functions performed at the SDC position included: (1) handling of Service-B traffic, (2) handling of Service-A traffic which had to be manually manipulated, (3) coordination with military base operations in the area for flight plans and movement messages, and (4) responsibility for initiation of search and rescue procedures for overdue aircraft. This position was generally considered to be the most difficult to learn in the facility in terms of computer operation. The specialist at this position had to follow a complex set of procedures to handle a wide variety of circumstances which might be encountered. A more detailed operational discussion relating to the SDC position and the associated Service-B workload is contained in a subsequent section of this report.

The final major component of the AWANS system was an administrative,

support and monitor function. Within the administrative classification were statistical reports generated by the system which provided activity listings by individual position, class of positions, facility, or by the entire system. The report included the number of flight plans entered by type and the number of pilot weather briefings performed. Additionally, a historical record was kept of weather information received and items requested from each terminal. This report was entitled "Event Reconstruction." Together with recorded voice tapes of specialist-to-pilot transactions, this report was used as a training aid to enhance specialist operation, procedures, and techniques. In addition, the data elicited therefrom could supply needed information in case of an aircraft mishap.

Support functions included the capability to cause selected graphics to be shown on group displays (23-inch CRT monitors). Additionally, there was a capability of selecting dialable radar sites for the display of weather information and the means to vary the timing interval at which the images were updated. The system allowed the assistant chief wide latitude to reconfigure position activities or to disable a position entirely. The system alerted the assistant chief whenever a match was made between an aircraft entered into the system and the identification of other aircraft on an internally stored list. This capability could be used for discovering overdue aircraft or for notification of contact with stolen aircraft.

The system could be automatically searched for an aircraft identification in the case of an incident or accident. However, there were certain restrictions on this capability. The search had to be conducted offline, and if the event was recent, the current record of activity had to be removed and replaced. Additionally, the transaction must have involved either the entry of an aircraft identification in specified Service-B formats or the filing of a flight plan. The action of pilot weather briefing alone would not cause a match within the system. To the extent possible the system was designed to eliminate manual recordkeeping.

The AWANS operating system automatically monitored the status of display and communication lines and several internal states including buffer, disk and processor status. Whenever a significant change occurred, a message was displayed to either the assistant chief or the data systems specialist on duty. Furthermore, many system messages were displayed to the operational specialists to prompt them in the entry of flight plans or requests for weather data.

The route and airway structure of the continental United States was contained in the data base of the system together with the locations of weather stations and types of reports available from these reporting stations. Although not specifically an operational feature, this data base had a significant operational impact on flight plan filing. All routes and location identifiers were checked against the data base to locate the appropriate weather reporting locations. This in effect validated the route. Monthly updates were received in the form of digital tape and entered into the system at designated intervals.

AWANS DATA COLLECTION PROGRAM.

The data collection program was directed toward quantifying the performance of the AWANS so that the effect of any changes to the system could be measured. Data collection started in August 1975 and continued until September 1976. By March 1976 the operation of the system had stabilized and it was, for most part, operating as was intended.

Three types of data were collected:

A. Objective Measures
   1. Preflight Briefing Positions (Counts, Time, and Number of Pages)
   2. In-flight Briefing Positions (Subtask timing and counts)
   3. System Data Coordinator Position (Subtask timing and counts)

B. Subjective Measures
   1. Specialist Opinion Surveys
      a. Part I. General Items
      b. Part II. Specific Items
      c. Part III. Display Configurations
   2. Modified Products Survey (Evaluation of improved content and formats)
   3. Structured Interviews

C. Environmental Measures
   1. Lighting Levels
   2. Subtended Visual Angle of the CRT Displays
   3. Noise Levels

A large volume of data was collected manually; key punched, and summarized by computer. Statistical reports on the preflight position data and the specialist opinion surveys were generated. Periodically, during the data collection period, these reports were collated and sent to the Systems Research and Development Service (SRDS). A total of eight data reports comprising some 2,500 pages was submitted by NAFEC. This information remains on file at NAFEC for perusal by interested parties. The data presented in this report represent a small portion of the total collected. Although a work statement was prepared to define the detailed requirements for an automated data collection, reduction, and analysis system, funding limitations precluded its development, and all data were collected manually. The existing AWANS activity recording tapes and event reconstruction and statistics reporting programs could not be adapted to our data collection requirements.

OBJECTIVE MEASURES. The bulk of objective measures was collected on the preflight briefing positions. The amount of time spent and the number of pages accessed were measured for the individual types of material accessed during the briefing (flight plan format, weather text, maps or radar, and other printed reference material), and for the transaction as a whole; i.e., from the initiation of contact with the pilot to the termination of contact. These data were further categorized by console configuration, group CRT monitor status, type of flight plan, type of transaction (weather briefing only, flight plan filing only, and combined flight plan filing and weather briefing) and local weather conditions. This classification along with counts of the transaction according to types of material accessed provide a valuable statistical profile of the AWANS operation. Task analyses (timing and task count) were performed on the in-flight briefing position and system data coordinator position. Hourly system communications loadings were determined for a period of a week. The

system response times, that is, the time delay between the keying of a function and the first appearance of alphanumerics or graphics on the CRT, were measured for 15 different system functions. The times required to write a typical page of data were also measured.

SUBJECTIVE MEASURES. The subjective measures were in the form of three specialist opinion surveys (SOS I, II, and III) and a system improvement report (SIR). SOS I treated general aspects of AWANS, whereas SOS II treated specific aspects of the system operation and design. Both were administered August 1975, October 1975, December 1975, and July 1976. SOS III solicited specialist preferences for 21 possible console and group display configurations. The SIR was a form on which suggestions could be submitted.

ENVIRONMENTAL MEASURES. Environmental factors including lighting levels, noise levels, and subtended visual angles of the CRT displays were measured. A photographic survey of the AWANS equipment, consoles, and workspace arrangement was conducted.

The wide range of measures were taken in order to: (1) permit a detailed characterization of the operation of AWANS, (2) indicate what the specialists think about it, and (3) point the way to improvements for follow-on systems.

ADVANTAGES OF AN AUTOMATED MONITORING AND DATA COLLECTION SYSTEM.

All of the objective data collected at the specialists' positions involved an observer sitting near the position. The mechanics of the data collection required operation of a calculator/timer and marking of a data form. The observer also listened to the transaction by means of a headset. The specialist was aware that his actions were being monitored, timed, and recorded. This awareness may have altered his usual style of providing flight services. He may have "gone by the book" more than he normally would. With the passage of time, however, it is likely that the specialists became habituated to the presence of the observer and that their behavior then reverted to their usual mode of operation. It was impossible to determine the effect this "over-the-shoulder" observation method had on the specialists' performance.

The use of a computer-based monitoring and data collection system would eliminate this perturbing effect. Use of such an automated system would also make data available on all the specialists 24 hours a day, 7 days a week, and 52 weeks a year a practicable undertaking. Changes in the operation of the system due to time of day, day of the week, and season could be easily determined. As mentioned earlier, a work statement for such an automated system was prepared and is on file at NAFEC. A paramount deficiency with the existing automated AWANS data collection system is the inadequate operational definition of the end of a transaction.

RESULTS

PREFLIGHT TELEPHONE TRANSACTIONS. (How long did it take to file a flight plan, give a weather briefing, or do both?)

Table 2 shows transaction counts and transaction times by month, local

TABLE 2. PREFLIGHT POSITION TELEPHONE TRANSACTION COUNTS AND MEAN TIME PER CALL BY MONTH, BY LOCAL WEATHER CONDITION, AND BY TYPE TRANSACTION

Local Weather Conditions		VFR			MVFR			IFR		
Type of Transaction		FP	FP & WX	WX	FP	FP & WX	WX	FP	FP & WX	WX
1976										
March	Count	26	70	118	8	39	158	3	26	74
	Mean Time	2.68	4.40	2.26	3.62	6.66	2.62	1.43	5.34	3.09
May	Count	15	44	108	3	15	41	7	15	66
	Mean Time	2.92	6.35	2.87	2.81	5.91	3.77	2.06	4.68	2.56
August	Count	72	127	226	44	107	282	3	15	33
	Mean Time	1.87	4.35	2.61	1.78	4.49	2.37	3.19	5.06	2.91

(Time is in decimal minutes)

weather condition, and type transaction. Standard errors for the transaction times, mean number of pages per transaction, time per page, and percentages relative to several bases have been computed and are on file at NAFEC.

The data in table 2 illustrate the variation in transaction times. The number of MVFR transactions in August is somewhat misleading. Actually, the weather was generally good; however, morning fog reduced the minimums so that during the early morning hours the local weather conditions had to be classified MVFR. Also, the times for filing flight plans were handled somewhat differently in the August data collection period; i.e., for transactions in which multiple flight plans were filed, each flight plan filing was treated as a separate transaction. It was thought that this would have a minimal effect on the data; however, it did produce a noticeable decrease in the mean flight plan times. The number of counts in table 2 range from a minimum of 3 to a maximum of 282. The greater the count number is, the more representative the transaction time is.

Table 3 shows the same preflight position data as in table 2 except times are averaged over the three transaction types. This provides data on the overall time per call or time per transaction without regard to what kind of transaction occurred. The times range from a minimum of 2.84 minutes for MVFR local weather in August to a maximum of 4.27 minutes for MVFR weather in May. The two considerations mentioned in the above paragraph regarding the August weather and data collection method may be partially responsible for the lower value for transaction time in August.

Table 4 shows the same data as in table 2, except the data are averaged over the three local weather conditions. In this table, the times range from a minimum of 1.87 minutes for flight plan filing in August to a maximum of 5.92 minutes for combined transactions in May. Times for the flight plan filings and combined transactions are lower for the August data. This is probably due to the different treatment of the multiple flight plan transactions and not due to any significant change in the transaction times themselves. The rightmost three columns showing percent frequency of occurrence of the transaction types support this. Percentages for March and May are consistent, whereas the number of transactions involving flight plans are greater for August.

Table 5 shows the same data as in table 2 except averaged over the three types of transactions and the three local weather conditions. Variation in transaction time over the 3 months does not indicate a progressive decrease, as might be expected if briefing times decreased with experience. The shorter time for August was explained in the above paragraphs. Thus, no learning effect can be demonstrated with these data.

Table 6 shows the same data as in table 2 except averaged over the 3 months of data collection. In the three-by-three type transaction by local weather condition table, the minimum time is 2.10 minutes for flight plans filed under the MVFR condition, and the maximum time is 5.15 minutes for combined transactions filed under MVFR local

TABLE 3. PREFLIGHT POSITION TELEPHONE TRANSACTION COUNTS AND MEAN TIME PER CALL BY MONTH AND BY LOCAL WEATHER

Local Weather Conditions		VFR	MVFR	IFR
1976				
March	Count	214	205	103
	Time Per Call	3.01	3.43	3.61
May	Count	167	59	88
	Time Per Call	3.79	4.27	2.88
August	Count	425	433	51
	Time Per Call	3.00	2.84	3.56

(Time is in decimal minutes)

TABLE 4. PREFLIGHT POSITION TELEPHONE TRANSACTION COUNTS AND MEAN TIME PER CALL BY MONTH AND BY TYPE TRANSACTION; FREQUENCY OF OCCURRENCE IN PERCENTAGE IS ALSO SHOWN

					Percent Frequency of Occurrence		
Type of Transaction		FP	FP & WX	WX	FP	FP & WX	WX
1976							
March	Count	37	135	350	7.1	25.9	67.0
	Time Per Call	2.79	5.23	2.60			
May	Count	25	74	215	8.0	23.6	68.5
	Time Per Call	2.66	5.92	2.94			
August	Count	119	249	541	13.1	27.4	59.5
	Time Per Call	1.87	4.45	2.51			

(Time is in decimal minutes)

TABLE 5. PREFLIGHT POSITION TELEPHONE TRANSACTION COUNTS AND MEAN TIME PER CALL BY MONTH AND PERCENT OCCURRENCE OF LOCAL WEATHER CONDITIONS

1976			Percentage of Local Weather: VFR	MVFR	IFR
March	Count	522	41.0	39.3	19.7
	Mean Time	3.29			
May	Count	314	53.2	18.8	28.0
	Mean Time	3.62			
August	Count	909	46.8	47.6	5.6
	Mean Time	2.95			
Across Months	Count	1,745			
	Mean Time	3.17			

(Time is in decimal minutes)

TABLE 6. PREFLIGHT POSITION TELEPHONE TRANSACTION COUNTS AND MEAN TIME PER CALL BY LOCAL WEATHER CONDITION AND BY TYPE TRANSACTION

Local Weather	Type of Transaction	FP	FP & WX*	WX	Across Rows
VFR	Count	113	241	452	806
	Mean Time	2.20	4.73	2.58	3.17
MVFR	Count	55	161	481	697
	Mean Time	2.10	5.15	2.57	3.13
IFR	Count	13	56	173	242
	Mean Time	2.18	5.09	2.85	3.33
Down Columns	Count	181	458	1,106	1,745
	Mean Time	2.17	4.92	2.62	3.17

(Time is in decimal minutes)

* Note that the sum of FP & WX on a given row approximates the time for a combined FP and WX

weather conditions. The rightmost column shows the values for all transactions under the three local weather conditions. There is no significant variation among these times. The bottommost row shows the average values for the three transaction types over all the other variables. These three averages represent the best estimates of the transaction times for specialists using the AWANS: 2.2 minutes for flight plan filing, 4.9 minutes for combined flight plan filing and weather briefing, and 2.6 minutes for weather briefing only.

Table 7 shows the overall summary statistics for the preflight telephone transactions by type of transaction and for all transactions combined measured during the months of March, May, and August 1976. The first two columns show total transaction counts and mean transaction times. The third column of data shows the standard error of the mean for transaction time. Plus or minus two times the standard error defines the 95-percent confidence interval about the mean value. Specifically, this means that if another 458 combined transactions were measured, the mean calculated from this new set of data would fall within plus or minus 0.24 minutes of 4.92 minutes 95 percent of the time, and only 5 percent of the time would the mean would fall outside this range due to purely random variations in the data. It is reasonable, therefore, to state with confidence that the true value of the time required for a combined flight plan filing and weather briefing lies within the range from 4.68 to 5.16 minutes.

The range for flight plan filing is 1.93 to 2.41 minutes. The range for weather briefings is 2.52 to 2.72 minutes. The range for all transaction types combined is 3.08 to 3.28 minutes. However, randomness depends upon the action of a large number of factors which in themselves may not be random. Due to our method of data collection, it was possible to categorize the data into classes depending upon the contents of the transaction; i.e., the types of data accessed. This factor, called "complexity," is responsible for a considerable amount of the variation in number of pages accessed and transaction time. This factor is treated in the discussion of the next table. The remaining variables shown in table 7 are, from left to right: total number of pages, mean number of pages per transaction (either accessed on the CRT or printed reference material), standard error of the mean number of pages per transaction, the total time spent on all transactions, and the mean time per page.

The 3 months of data collection represents 5,542.61 minutes or 92.4 hours of collected data on 1,745 preflight telephone transactions. Dividing the former by the latter yields an overall mean transaction time of 3.17 minutes. There are two other observations which are of interest in table 7. With AWANS, the transaction time for flight plan (FP) only operations is now smaller with AWANS than the WX only transaction; i.e., 2.17 vs. 2.62. In the staffing standard the normalized weighting factors are 1.95 vs. 4.54, respectively, for a manual operations environment. The indication here is that the FP transaction labor intensity is considerably reduced with automation.

The other observation in table 7 is that the FP + WX transaction times

TABLE 7. SUMMARY STATISTICS FOR PREFLIGHT POSITION TELEPHONE TRANSACTIONS

Transaction Type	Total No. Trans.	Mean Trans. Time	Std. Err. Trans. Time	Total No. Pages	Mean No. Pages Per Trans.	Std. Err. No. Pages	Total Time Over All Trans	Mean Time Per Page
FP	181	2.17	0.12	307	1.70	0.10	391.85	1.28
FP & WX	458	4.92	.12	3908	8.53	.26	2,252.79	.58
WX	1106	2.62	.05	7035	6.36	.17	2,897.98	.41
All Trans.	1745	3.187	.05	11,250	6.45	.14	5,542.61	.49

are essentially equal to the sum of the mean transaction times for FP and WX only. Apparently the WX transaction time does not depend on whether or not a FP is included in the transaction; i.e., the WX part of mixed transactions is the same as WX only transactions.

THE RELATIONSHIP BETWEEN TRANSACTION COMPLEXITY AND DURATION.

The transactions were subdivided by the times taken for the different types of material given. Four categories were used: weather text accessed via CRT (WX), flight plan format accessed via CRT (FP), maps or radar accessed via CRT (GR), and references to other printed reference material (OR). The greater the number of types of material referenced, the more complex the transaction could be considered.

Table 8 presents a compilation of the data on transaction complexity. There are 15 possible combinations of the four categories of transaction contents. These combinations are listed in the third column from the left in the order of frequency of occurrence, the first being the most frequent. The leftmost column shows rank by frequency of occurrence. The second column from the left shows mean transaction time. The minimum time was 1.86 minutes for transactions in which only OR was accessed. The maximum time was 7.04 minutes for transactions in which all four categories; FP, WX, GR, and OR, were accessed. The fourth column shows the percent frequency with which a particular combination of reference material occurred across all the transactions monitored. Reference to weather text, WX was by far the most frequent occurrence. The fifth column shows cumulative totals of the percent frequency shown in the fourth column. The sixth column shows percentage of time spent in a given transaction content category and the rightmost column shows the cumulative total of the time percentages. Actual numbers of transactions and total time appear below table 8. Using these values multiplied by their respective percentages (in columns 4 and 6), the actual number of transactions and times can be computed.

The information in table 8 is valuable for determining the kinds and amount of information used by the specialist for preflight telephone briefings. It can be used to make a decision as to whether certain categories of printed reference material should be made available on the CRT and so forth. In summary, WX was accessed in 87.6 percent of the transactions, FP was accessed in 36.7 percent, GR was accessed in 20 percent, and OR was accessed in 12.7 percent of the transactions.

EFFECT OF CRT MONITOR STATUS, CONSOLE CONFIGURATION, OR LOCAL WEATHER CONDITIONS ON TRANSACTION TIMES.

Several varied information-producing equipment configurations were available to the preflight briefers. This section addresses the effects of the different configurations. Specifically, three independent variables are discussed; i.e.,

1. The status of the five 23-inch graphics displaying CRT monitors (on or off).

2. a. The individual CRT at the briefer's position displaying graphics and textual data.

TABLE 8. PREFLIGHT POSITION TRANSACTION COMPLEXITY STATISTICS RANKED BY FREQUENCY OF OCCURRENCE (MARCH, MAY, AND AUGUST 1976 DATA)

Rank Frequency of Occurrence	Mean Time Per Trans. (min.)	Trans. Content (Type Material Accessed) **	Percent Frequency of Trans. *	Cumulative Percentage of Frequency	Percent of Total Time ***	Cumulative Percentage of Time ***
1	2.28	WX only	45.2	45.2	32.4	32.4
2	4.06	FP & WX	14.2	59.4	18.1	50.5
3	3.49	WX & GR	13.0	72.4	14.3	64.8
4	2.17	FP only	10.4	82.8	7.1	71.9
5	6.16	FP, WX, OR	7.2	90.0	13.9	85.8
6	5.04	FP, WX, GR	3.3	93.3	5.2	91.0
7	3.49	WX & OR	2.4	95.7	2.6	93.6
8	04	FP, WX, GR, OR	1.4	97.1	3.2	96.8
9	2.15	GR only	1.3	98.4	.9	97.7
10	6.14	WX, GR, OR	.9	99.3	1.7	99.4
11	1.86	OR only	.6	99.9	.4	99.8
12.5	5.35	FP & OR	.1	100.0	.2	100.0
12.5	2.60	FP, GR, OR	.1	100.1	.1	100.1
14.5	--	FP & GR	.0	100.1	.0	100.1
14.5	--	GR & OR	.0	100.1	.0	100.1

* total number of transactions (equals 1,745)

** means WX text was accessed and displayed on a CRT

*** total time (equals 5,542.61 minutes)

FP means - flight plan data were entered via keyboard

GR means - graphics (maps and/or radar) were called up and displayed on a CRT

OR means - other reference material such as airmen's information manual, airport directory, etc. were accessed

WX was accessed in 87.6% of transactions

FP format was accessed in 36.7% of transactions

GR data were accessed in 20.0% of transactions

OR was consulted in 12.7% of transactions

b. The dual CRT at the briefer's position displaying graphics on one CRT and textual data on the other.

c. The shared CRT which served a briefer seated on either side and provided graphics only while textual data were provided on individual CRT's.

3. Local weather conditions.

The intent was to determine how such variables impacted the amount of time expended and the number of pages of data accessed for a transaction. A balanced factorial data collection protocol was executed in August 1976. Data on 909 transactions were collected.

Analyses of variance were performed to test for the effects of the three independent variables. A total of 24 analyses of variance were performed. Only one analysis satisfied the statistical and relational criteria. This analysis showed that when the group CRT monitors were turned off, there was an appreciable increase in the amount of time and number of pages of data accessed in order to complete a combined WX/FP transaction. The results are shown in table 9.

There is a causal relationship between the number of pages accessed and the time required to give a briefing. It would be expected that if the specialist could not obtain the graphical information required from the group CRT monitors, that they would access that information via their console displays. It is obvious from the greater number of pages accessed and the longer briefing time in the "monitors off" condition that this is what they, in fact, did.

There were two variables that demonstrated the effect of group CRT monitor status more than transaction time or number of pages accessed. The two variables, i.e., percent of transactions during which graphics were accessed and percent of transaction time spent on graphics, are plotted in figure 2. The percentages are plotted versus the number of CRT's at the three different console configurations. Two facts are obvious in looking at the graph: the percentages are lower when the CRT monitors are on, and there is a decrease in the difference between the on and off conditions as the number of CRT's at the position increases. This latter observation led to the speculation that if there were enough CRT's at the specialists

TABLE 9. THE EFFECT OF GROUP CRT MONITOR STATUS ON TIME AND PAGE COUNT FOR COMBINED WX/FP BRIEFINGS

	Monitor Status			
	Off	On	Diff.	Signif.
Time (Min)	4.7	4.1	0.6	.05
Page Count	8.3	7.6	0.7	.10

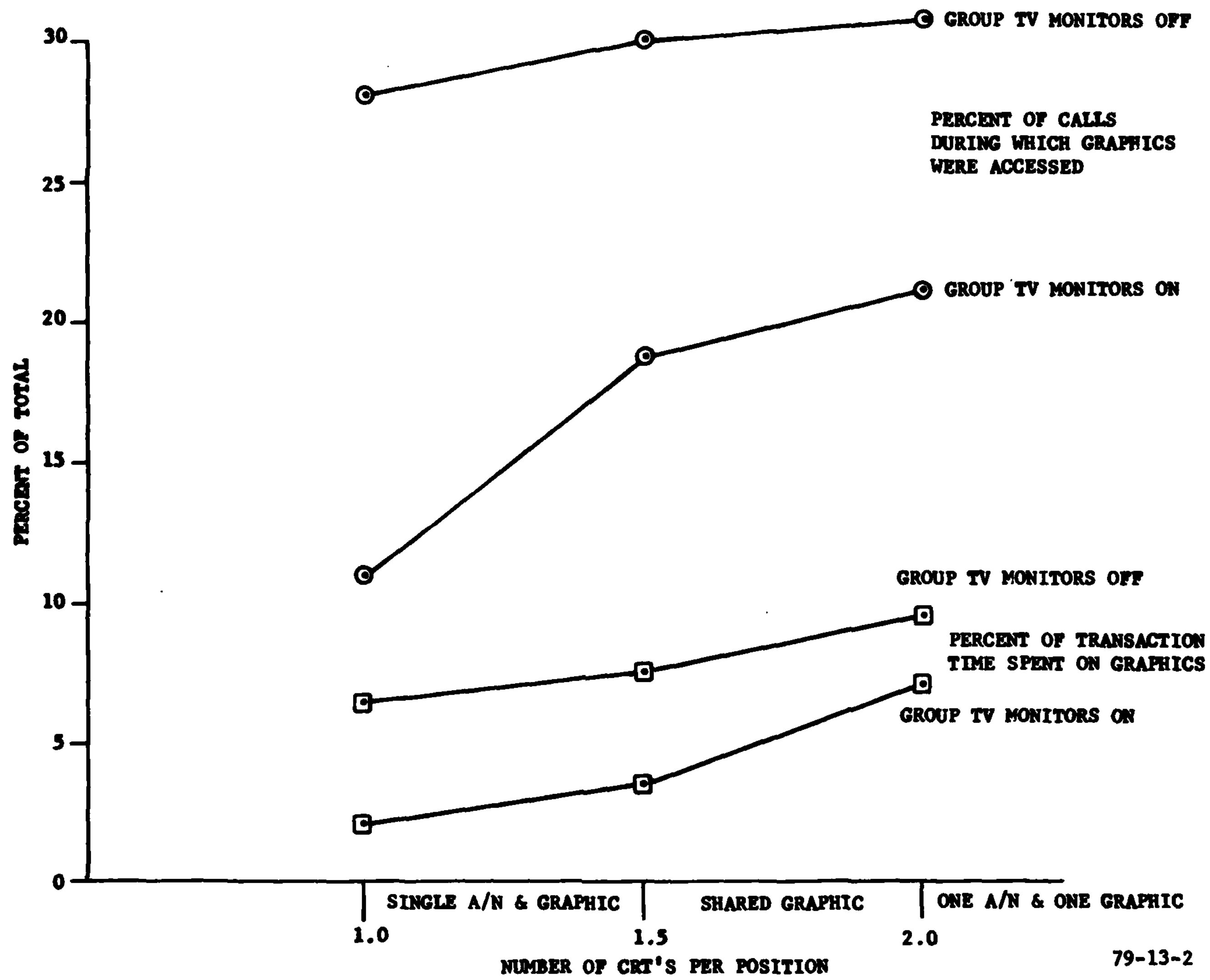


FIGURE 2. PLOT OF OBJECTIVE DATA ON GRAPHICS USAGE: PERCENT ACCESSES AND PERCENT OF TIME

position, there would be no difference in these two variables due to turning the group CRT monitors on or off; i.e., give the specialist enough displays at the console position and there would be no need for group displays. What should this number of CRT's at the position be? Figure 3 shows the differences (monitors off minus monitors on) for both the variables. Regression lines were fitted through the three points. The regression lines converge in the vicinity of three CRT's. This means that if each specialist had three CRT's at his position, he would have no need of more distant group CRT monitors.

The best arrangement of three CRT's would seem to be to use one of them for textual material only, one for textual material or graphics, and one for graphics only. This would make possible using one CRT to display weather text, using the second for flight plan data, and using the third for a weather map. Alternatively, one CRT might be used for weather text, while the other two were being used for displaying graphics.

The results obtained above are dependent on the particular operating system in use on the AWANS. A data display system that was optimized for ease of access to either graphical or textual data, with the ability to return to a particular point in weather text display or in flight plan format after having accessed a map or radar, might show that the need for group CRT monitors is eliminated with only two CRT's at the display.

IN-FLIGHT POSITION TASK ANALYSIS.

Table 10 shows times and action counts taken on the in-flight position over a total time period of 709.33 minutes. Within this interval, the specialist was busy for a total of 312.72 minutes and was thus occupied 44.1 percent of the time. During this period, the specialist activated 33 flight plans at 1.56 minutes mean duration, gave 30 weather briefings at 1.85 minutes mean duration, and filed 14 flight plans at 2.97 minutes mean duration. Seventy-six of his actions fell in the "Other" category and accounted for 12.8 percent of the total observed time. The activity requiring the longest time on the average was that of "Broadcast." There were 13 of these actions, with a mean duration of 3.24 minutes.

SYSTEM DATA COORDINATOR TASK ANALYSIS. (Special attention is paid to this function since it is new and peculiar to AWANS.)

The system data coordinator (SDC) position within the AWANS system consists of two positions, each with a single alphanumeric terminal. The operational responsibilities of this position include actions within the following areas: handling of Service-B flight-related messages, response to time-alerted messages, handling of erroneous and outdated weather-related Service-A reports, coordination with military base operations, and origination of messages on overdue aircraft.

To provide data on the amount of work performed at the SDC position and the time required, the position operation was monitored using a digital timer. From these observations, tallies were made of the number of Service-B messages received. Additionally, the number of actions initiated by a specialist, i.e., actions in response to messages

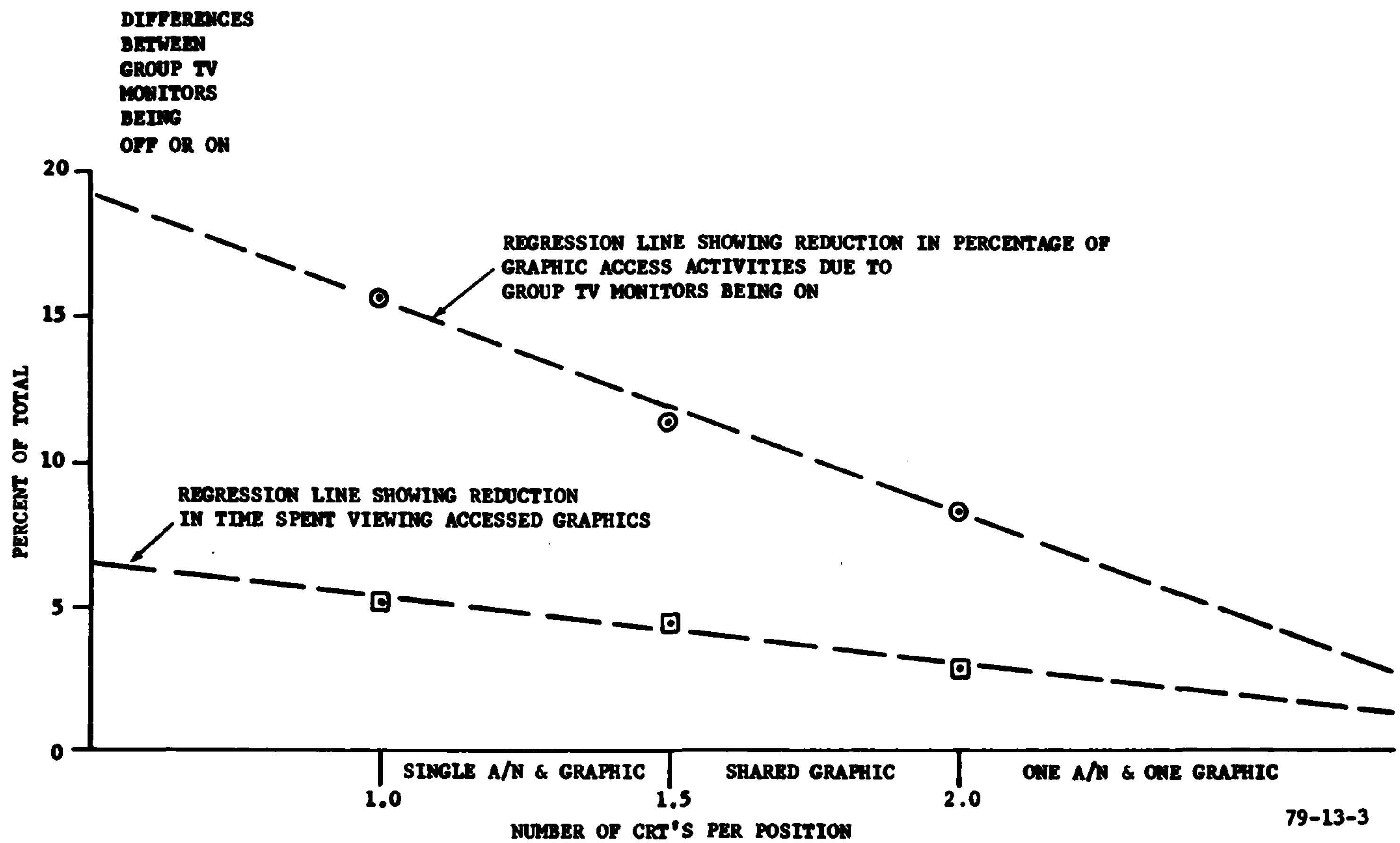


FIGURE 3. OBJECTIVE DATA SHOWING EXTRAPOLATIONS SUGGESTING THE EQUIVALENCE OF A THREE-CRT CONSOLE TO A FIVE-CRT MONITOR GROUP CONFIGURATION

TABLE 10. IN-FLIGHT POSITION TIMING AND ACTION COUNT

July 1976

Total Observed Time = 709.33 Minutes

Operations

Type of Activity	No.	Total Time (min)	Mean Time (min)	Std. Error (min)	Percent of Observed Time
Position Report	7	7.55	1.08	0.36	1.0
Clearance Request/Relay	5	9.72	.94	.40	1.3
Weather Briefing	30	55.38	1.85	.16	7.8
Pilot Report	2	5.37	2.68	.74	.7
Flight Plan	14	41.63	2.97	.32	5.9
Airport Advisory Service	0	0.0	0.00	.00	0.0
In-Flight Assist	0	0.0	0.00	.00	0.0
Flight Plan Activation	33	51.63	1.56	.11	7.3
Flight Plan Closure	8	8.67	1.08	.19	1.2
Broadcast	13	42.17	3.24	.43	5.9
Other	76	90.60	1.19	.12	12.8
Total all Activities	188	312.72	1.66	.07	44.1

timed out, actions in response to a call from military base operations, or actions in response to pilot inquiry, are included under Flight Information Handling.

The types of activities for Service-B and Flight Information are closely related. Actions in response to the Service-A queue are defined as well as use of the flight plan entry format and general message format for position-to-position and other messages. Sampling was done on a single position during the period 0700 to 1700 local time from July 19 to July 23, 1976. Moderately active traffic was encountered during this period.

The system data coordinator is a new function not required in a manually operated FSS. It is a position critical to the success of the automated operation. For this reason considerable time was spent in analyzing the tasks and subtasks of this position. Although the 773.5 minutes of observation time is considerably less that the 5,542.6 minutes spent on the preflight position, the data have been separated into categories which provide much information on the function of this position. A total of six tables delineate the results.

Table 11 shows the data categorized by five types of information, as listed in the leftmost column. The data in table 11 represent a summary of the contents of tables 12 through 15. Inbound Service-B messages are the most frequent events and also occupy the largest amount of time. During the period of observation, the system data coordinator was busy for 76.4 percent of the time accounting for 580 operations at 1.02 minutes mean duration. There were 22 flight plan operations at 2.40 minutes mean duration.

Table 12 shows a further breakdown of the action counts for the inbound Service-B operations as listed in table 11. The most frequent actions across both civil and military messages were in order: Cancel, Handwriting, Mapping, Search Lists, Transmit Service-B Messages, and Other.

Table 13 shows the analysis of the actions involved in the 119 flight information requests for both civil and military pilots. The most frequent flight information request action was Search Lists, followed by Telephone, Handwriting, References, Transmit Service-B Message, and Cancel.

Table 14 shows the analysis of actions involved in the 159 Inbound Service-A messages. The messages are divided into two classes, weather and NOTAM. Of the 159 messages, 109 required no action, 23 required removal from, and 21 required insertion into the system. A typical weather action required 0.20 minutes, whereas a typical NOTAM action required 0.53 minutes.

Table 15 separates the flight plan actions into four different types of flight plans. During the time of operation there were 19 military and 3 civilian flight plans handled. The mean duration of the military flight plan action was 2.38 minutes, whereas the mean duration of the civilian flight plan action was 2.84 minutes.

TABLE 11. SYSTEM DATA COORDINATOR TIMING AND ACTION COUNT

July 1976

Total Observed Time = 773.50 Minutes

Type of Information	No.	Total Time (min)	Mean Time (min)	Std. Error	Percent of Observed Time
Inbound Service-B	280	342.82	1.22	0.13	44.3
Flight Information Handling	119	150.52	1.26	.12	19.5
Inbound Service-A	159	44.58	.28	.04	5.8
Flight Plan	22	52.70	2.40	.30	6.8
General Message	0	0.0	0.0	.0	0.0
All Operations	580	590.62	1.02	.07	76.4

TABLE 12. SYSTEM DATA COORDINATOR INBOUND SERVICE-B ACTION COUNT, JULY 1976

	Civil	Military	Total
No. of Inbound Service-B Messages	199	81	280
Required Actions			
Handwriting	110	20	130
Tsmt Service B-Message	48	34	82
Search Lists	60	34	94
Telephone	4	20	24
References	8	4	12
Print	4	3	7
Mapping	97	10	107
Cancel	122	35	157
Other	40	42	82
No Action	13	4	17
Total	506	206	712
No. of Actions per Message	2.54	2.54	2.54
Total Time Dealing with Service-B Messages (minutes)	207.70	135.12	342.82
Mean Time per Message	1.04	1.67	1.22
Standard Error	.17	.15	.13

TABLE 13. SYSTEM DATA COORDINATOR FLIGHT INFORMATION ACTION COUNT, JULY 1976

	Civil	Military	Total
No. of Flight Information Requests	71	48	119
Required Actions			
Handwriting	20	15	35
Tsmt Service B-Message	8	15	23
Search Lists	47	21	68
Telephone	18	23	41
References	16	15	31
Print	0	0	0
Mapping	1	0	1
Cancel	14	9	23
Alert	2	1	3
Total	126	99	225
No. of Actions per Message	1.77	2.06	1.89
Total Time with Flight Information (minutes)	69.32	81.20	150.52
Mean Time per Message	.98	1.69	1.26
Standard Error	.15	.19	.12

TABLE 14. SYSTEM DATA COORDINATOR INBOUND SERVICE-A ACTION COUNT, JULY 1976

	Type of Information Displayed		
Required Action	Weather	NOTAM	Total
Insert	7	14	21
Amend	2	2	4
Remove	15	8	23
Print	0	2	2
No Action	90	14	109
Total of Items Displayed	114	40	159
Total Time of Actions (minutes)	23.30	21.28	44.58
Mean Time of Action per Item	.20	.53	.28
Standard Error	.04	.09	.04

TABLE 15. SYSTEM DATA COORDINATOR FLIGHT PLAN ACTION COUNT, JULY 1976

Type of Flight Plan	No.	Total Time (min)	Mean Time (min)	Standard Error
Military	19	45.18	2.38	0.31
VFR	1	1.53	1.53	-.00
IFR (low)	1	1.98	1.98	-.00
IFR (high)	1	5.00	5.00	-.00
Other	0	0.00	0.00	-.00
All Flight Plans	22	52.70	2.40	.30

Table 16 shows representative Service-B message types with seven categories under each of two classes: messages received and messages transmitted. Under Messages Received, Acknowledgement accounted for 37.6 percent of the total, and the second largest was Flight Information accounting or 8.3 percent of the total. Under Messages Transmitted, Acknowledgement accounted for 12.2 percent of the total, and the second largest was Flight Plan (military) accounting for 5.5 percent of the total. Combining the data for messages received and transmitted indicates that 49.8 percent of the total message types involved Acknowledgement. It is obvious that any means of automating, even partially, the Acknowledgement function could result in considerable savings in the workload on the System Data Coordinator.

SYSTEM RESPONSE TIMES.

An important aspect to the usability of a data system is the time the system takes to respond to a request from the user. The AWANS design specifications required a response time of 3 seconds or less on 95 percent of the requests for data. Although it was not the intention of this experiment to determine specification compliance, it was of sufficient interest to warrant an independent determination. To determine what these times were, data were collected in October 1976. At this time, the system had been operating for about 15 months. Data were collected with an electronic stopwatch. Fifteen functions were exercised so that the results would be representative of the overall functioning of the system. The values obtained were averaged, and the results are shown in table 17. It can be seen that the initial response time (the time from pressing the execute key until data began appearing on the CRT) of 1.6 ± 0.2 seconds is well within the original specifications. Even the initial time plus the time required to display a page of data (initial plus write) was only 2.0 ± 0.3 seconds. Comments from the specialists at the Atlanta FSS indicated that they were satisfied with the response times of

TABLE 16. SYSTEM DATA COORDINATOR POSITION REPRESENTATIVE SERVICE-B MESSAGE TYPE DAILY WORKLOAD

	Mean No.	Std. Err.	Percent of Total
Messages Received			
Flight Notification			
IFR	0.33	1.00	0.0
VFR	32.00	1.00	4.9
Military	32.00	1.00	4.9
Other	.33	1.00	0.0
Acknowledgement	244.67	26.19	37.6
Administrative	16.67	2.96	2.6
Flight Information	54.00	9.54	8.3
Equipment Status	10.33	2.03	1.6
Error Message	13.33	1.20	2.0
Other	39.00	6.56	6.0
Subtotal	442.67		68.0
Messages Transmitted			
Flight Plan			
IFR	34.67	13.35	5.3
VFR	7.67	2.33	1.2
Military	36.00	7.00	5.5
Other	1.33	.88	0.2
Acknowledgement	79.67	8.99	12.2
Administrative	1.00	1.00	0.2
Flight Information	20.67	3.53	3.2
Equipment Status	0.00	0.00	0.0
Error Message	4.33	.88	0.7
Other	22.67	1.33	3.5
Subtotal	208.00		32.0
Total	650.67		100.0

TABLE 17. AWANS SYSTEM RESPONSE TIMES

	Initial Response	Initial and Write	Write Only
Local Preflight Position	1.6 ±0.2	2.0 ±0.3	0.4 ±0.2
Dobbins AFB Remote Terminal	5.2 ±1.1	11.0 ±2.3	5.9 ±1.4
Remote Divided By Local	3.2	5.5	14.7

Mean times in seconds ±2 S.E. (95% conf. range) data collected October 1976.

the system. The situation was different, however, in the case of the response times at the remote terminals. At Dobbins Air Force Base (AFB) the initial response time was 5.2 ±1.1 seconds. And the initial plus write time was 11.0 ±2.3 seconds. Comments from the remote terminal users indicated dissatisfaction with these times. Certainly a wait of 5.2 seconds from the time the execute key is depressed until some system response becomes apparent is too long for someone who wants the data "instantaneously." The nature of the human perception of time is that a delay of 0.5 seconds or less is almost instantaneous, while a delay much greater than 2.0 seconds is perceived as being very long.

Since the greater time delays are both a function of the lower priority assigned to the remote terminals and the slower data rate of their telephone lines, it is suggested that any remote terminals have the capability of storing at the site the most frequently requested types of material. This would reduce the inconvenience to the specialist of "waiting forever" for requested data to be displayed.

FSS SPECIALISTS' OPINIONS OF AWANS.

Subjective measures were taken on specialists' reaction to both general items (nonequipment-related aspects) and specific items (equipment-related aspects) of automation by means of an eight-page, 144-item Specialist Opinion Survey. The 16 general items were questions phrased so as to evoke a comparison between the manual and the automated FSS and are, thus, relevant to the purpose of this report. The 128 specific items will not be discussed further here. For those interested, these data are on file at NAFEC.

Following activation of AWANS, the Specialist Opinion Survey was administered four times at the Atlanta FSS and once at the Macon FSS. The Atlanta surveys were conducted during August, October, and December 1975 and July 1976. The Macon survey was conducted during October 1975. The number of respondents ranged from 44 to 20 at Atlanta and 7 at Macon. Even though there were fewer respondents, it was deemed important to evaluate the specialists' responses at the AWANS satellite operation (remote terminals with relatively slow communication rates) at Macon. Known objective differences between the two configurations could then be related to differences in the subjective responses.

Part 1 of a sample FSS Specialist Opinion Survey is included as figure 4. The specialist was instructed to check the most appropriate of the five columns for each of the 16 aspects (rows a through p). The question was phrased to evoke a comparison of the situation after automation with that before. In the case of aspect f, the question would read, "Compared to manual procedures, use of AWANS involves:

. a large decrease

. a decrease

. no change

. an increase

. a large increase

in the thoroughness of briefing." The particular aspects or items were chosen to be representative of expected changes (both benefits and detriments) following automation.

FSS SPECIALIST OPINION SURVEY, PART 1, GENERAL ITEMS

Now that you have had some exposure to AWANS, we would like you to answer the following questions on the basis of your experience to date. This same opinionnaire will be administered several times as your operational use of AWANS increases. Differences between the answers will show in what ways operational experience has modified your views. Please give us your current opinions, not what you think we want to hear.

NAME: ______________________ DATE: ______________

NUMBER OF WEEKS OPERATIONAL EXPERIENCE: ________

POSITION/S WORKED: ______________ SHIFT/S WORKED: __________

1. Using your experience with both the manual and the automated systems, compare the two approaches on the basis of the following aspects. Check the most appropriate block for each aspect. Try to answer every item.

	Aspect on which comparison is to be made	Compared to manual procedures, use of AWANS involves (any change?) of aspects a. to p.				
		A Large Decrease	A Decrease	No Change	An Increase	A Large Increase
a.	Time required to give briefing					
b.	Job satisfaction					
c.	Work involved in data access					
d.	Utilization by private pilots					
e.	Overall ability to give an adequate briefing					
f.	Thoroughness of briefing					
g.	Work involved in taking flight plans					
h.	Speed of finding needed data					
i.	Likelihood of making an error					
j.	Amount of eyestrain					
k.	Ease of answering pilot queries					
l.	Utilization by corporate/military pilots					
m.	Amount of frustration					
n.	Confidence in system					
o.	Feeling of personal competence					
p.	Work involved in giving briefing					

Originator	Date	Quantity	APPROVED FORM
ANA-230	7/30/75	500	

1.

FIGURE 4. FSS SPECIALIST OPINION SURVEY, PART I, GENERAL ITEMS (1 of 2 Pages)

2. On the basis of the equipment and procedures used in AWANS, indicate your opinion of its suitability for operational use in all Flight Service Stations. Please check one of the four statements below.

   a. ______ Suitable, fine as is.
   b. ______ Suitable; but minor modification desirable.
   c. ______ Marginally suitable, major modifications necessary.
   d. ______ Unsuitable, idea is OK; but complete redesign essential.

3. Please use the space below to comment on any problems you may have with AWANS.

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2.

FIGURE 4. FSS SPECIALIST OPINION SURVEY, PART I, GENERAL ITEMS (2 of 2 Pages)

Some of the aspects overlap or would be expected to be correlated, e.g., "Time required to give briefing" and "Work involved in giving briefing." This provides a basis for checking the internal consistency of the answers.

The following integer numerical values were assigned to the five choices:

1 = a large decrease
2 = a decrease
3 = no change
4 = an increase
5 = a large increase

A mean and standard error of the mean were computed for each of the 16 aspects for each of the surveys at both facilities. Tests were performed to determine the statistical significance of the deviation of the mean response from the center of the scale (3 = no change). For those aspects whose means were significantly above 3.0, the consensus of the specialists was than an increase occurred in that aspect due to automation. If the mean fell significantly below 3.0, a decrease in that aspect was noted. Unless otherwise indicated, a confidence level of alpha equal to or less than .05 was used to determine significance of the "t" score.

The questions were phrased so that the expected answers would include a balance of "increase" and "decrease" responses to encourage a careful reading of the items and to discourage stereotyped answering. Items a, c, g, i, j, m, and p are "negatively phrased." This means that an increase in these aspects would, most likely, be an unfavorable finding, i.e., would be detrimental to the performance of the job. The remaining nine items are positively phrased, and an increase would be a favorable finding. For example, favorable findings would be indicated by an increase in "Thoroughness of briefing" and also by a decrease in "Work involved in data access."

Table 18 shows the results of part I of the Specialist Opinion Surveys completed by Atlanta FSS personnel. The aspects are listed in order of the magnitude of perceived change, 1 being the largest change. The third column from the left shows the number of surveys on which each aspect was perceived as changing significantly. The fourth column indicates whether that change was an increase or a decrease, and the rightmost column indicates the expected effect of this change on the performance of the job; i.e., whether it was favorable or unfavorable.

This table shows the effects of automation at Atlanta to be predominantly favorable. Fourteen of the aspects changed in a favorable direction, while only two changed in an unfavorable direction.

The 16 aspects can be subsumed under four main headings as follows:

1. Quality of Service

*a. Thoroughness of briefing.

*b. Overall ability to give adequate briefing.

*c. Utilization by private pilots.

d. Utilization by corporate/military pilots.

2. Morale of the Specialist

TABLE 18. RESULTS OF FSS SPECIALIST SURVEY ON THE EFFECTS OF AUTOMATION

ASPECT RANK (BY AMOUNT OF CHANGE)	ASPECT IN QUESTION	NUMBER OF SIGNIFICANT SURVEYS	CHANGE IN ASPECT	DIRECTION OF CHANGE
1	THOROUGHNESS OF BRIEFING	4	INCREASED	FAVORABLE
2	OVERALL ABILITY TO GIVE ADEQUATE BRIEFING	4	INCREASED	FAVORABLE
3	WORK INVOLVED IN DATA ACCESS	4	DECREASED	FAVORABLE
4	JOB SATISFACTION	4	INCREASED	FAVORABLE
5	AMOUNT OF EYESTRAIN	4	INCREASED	UNFAVORABLE
6	WORK INVOLVED IN GIVING BRIEFING	4	DECREASED	FAVORABLE
7	FEELING OF PERSONAL COMPETENCE	4	INCREASED	FAVORABLE
8	CONFIDENCE IN SYSTEM	4	INCREASED	FAVORABLE
9	TIME REQUIRED TO GIVE BRIEFING	3	DECREASED	FAVORABLE
10	EASE OF ANSWERING PILOT QUERIES	3	INCREASED	FAVORABLE
11	LIKELIHOOD OF MAKING AN ERROR	2	DECREASED	FAVORABLE
12	SPEED OF FINDING NEEDED DATA	2	INCREASED	FAVORABLE
13	UTILIZATION BY PRIVATE PILOTS	4	INCREASED	FAVORABLE
14	WORK INVOLVED IN TAKING FLIGHT PLANS	2	INCREASED	UNFAVORABLE
15	UTILIZATION BY CORPORATE/MILITARY PILOTS	2	INCREASED	FAVORABLE
16	AMOUNT OF FRUSTRATION	1	DECREASED	FAVORABLE

*a. Job satisfaction.

*b. Feeling of personal competence.

3. Task Performance/System Operation

*a. Work involved in data access.

*b. Work involved in giving briefing.

c. Time required to give briefing.

d. Ease of answering pilot queries.

e. Likelihood of making an error.

f. Speed of finding needed data.

g. Work involved in taking flight plans.

4. Adequacy of Equipment/Environment

*a. Amount of eyestrain.

*b. Confidence in system.

c. Amount of frustration.

* The items preceded by an asterisk are those in which statistically significant changes were perceived in all four surveys.

Based on this categorization, implementation of automation at Atlanta significantly improved both the Quality of Service and the Morale of the Specialist.

All of the aspects under Task Performance/System Operation showed favorable changes with the exception of "Work involved in taking flight plans." This aspect was increased in two of the surveys. Objectively, the amount of work done by the specialist in taking flight plans did increase. Instead of copying the flight plan on a form (about a 1.5-minute task) and handing the form to a teletype operator, the specialist is required to take the information and key it into the automated system (about a 2.0 minute task). So, this perceived change reflects an actual increase in work required of the specialist at this position. However, if the additional workload of the teletype operator is considered (including hand-carry time), the overall facility workload is actually reduced. The final category, Adequacy of Equipment/Environment, shows an increase in the "Amount of Eyestrain." This perceived change is related to the manner of obtaining weather text information from CRT displays at the specialist position and in the manner of viewing group monitor graphics. The use of these electronic displays necessitated reduction in the ambient room lighting. The specialist had been used to operating in daylight, and the reduction in overall lighting, unevenness of the artificial lighting, and the difference between reading data from a CRT screen rather than a printout contributed to the perceived increase in eyestrain. It should be noted that the ambient lighting system in the facility was not designed specifically for the AWANS environment. Whether there is, in fact, an increase in eyestrain with automation depends, in part, on the particular design features of the equipment and the environment. Good human factors design can minimize this potential negative effect of automation. The remaining two aspects under Adequacy of Equipment/Environment showed favorable changes.

Unlike the surveys at Atlanta, the survey at Macon showed five unfavorable changes and two favorable changes, as can be seen in table 19. These changes were due to the fact that the data rate to the remote terminal was low, and the time to respond to a keyboard request was longer (11 seconds at Macon compared to 2 seconds at Atlanta). This accounts for the unfavorable change in the first two aspects. The reason for the third unfavorable aspect change was discussed above. The fourth unfavorable change is related to the reliability problems associated with the remote terminal and the connecting phone lines. Eyestrain was discussed above; however, the lighting situation at Macon was not as objectionable as that at Atlanta. Another possible reason for the greater number of unfavorable changes at Macon is the information barrier due to the remoteness of Macon with respect to Atlanta. Finally, it is interesting that the only two favorable changes relate to Quality of Service and are the same as the two most notable changes at Atlanta.

After almost a year's experience with automation (August 1975 to July 1976) the subjective responses of the specialists to four of the general items, all within the Task Performance/System Operation area, showed a statistically significant favorable change (see table 20). In order of significance, these changes were:

1. Ease of answering pilot queries increased,

2. Time required to give briefing decreased,

3. Likelihood of making an error decreased, and

4. Work involved in giving briefing decreased.

It is important to note that the above four items are not objectively measured changes. Item 2 is a case in point. The specialists felt that the time to give a briefing decreased, whereas this time actually increased slightly after automation.

In addition to the specific changes between two surveys a year apart, as discussed in the preceding paragraphs, it is possible to see a trend in the attitude of the specialists across the four surveys as shown in table 20. The second column shows that there is an increasingly more favorable attitude of the specialists towards the automated system as time progresses. The rightmost column includes only the mean for "amount of eyestrain." That this aspect was not significantly unfavorable in December might be due to the fact that the reduced outdoor lighting of the winter season contrasted less with the indoor ambient lighting.

In summary, the Specialist Opinion Surveys showed a highly favorable opinion of automation at the central Atlanta facility and an unfavorable opinion at the satellite Macon facility. The latter opinion was due mainly to the much slower response time of the system. Automation at the central facility was perceived as having a favorable effect on Quality of Service, Morale of the Specialist, and Task Performance/System Operation. An increase in the "amount of eyestrain" was seen as an unfavorable change in the Adequacy of Equipment/Environment area. Over a period of a year's experience with the automated system, the attitude of

TABLE 19. RESULTS OF FSS SPECIALIST SURVEY ON THE EFFECTS OF AUTOMATION AT MACON, GEORGIA, FSS

Aspect Rank (by amount of change)	Aspect in Question	No. of Significant Surveys	Change in Aspect	Direction of Change
1	Amount of Frustration	1	Increased	Unfavorable
2	Time Required to Give Briefing	1	Increased	Unfavorable
3	Work in Taking Flight Plans	1	Increased	Unfavorable
4	Confidence in System	1	Decreased	Unfavorable
5	Amount of Eyestrain	0*	Increased	Unfavorable
6	Thoroughness of Briefing	0*	Increased	Favorable
7	Overall Ability to Give Adequate Briefing	0*	Increased	Favorable

*Significant at the Alpha $\leq .10$ Level

the specialists became increasingly more favorable.

AWANS VISUAL ENVIRONMENT.

The Atlanta FSS illumination scheme consisted of a primary room lighting system of fluorescent fixtures mounted parallel to the direction in which the preflight consoles were aligned. These fixtures were equipped with dimming ballasts and, as such, were controllable by solid state rheostats. Typically, the light level emanating from these fixtures was purposely kept quite low to insure minimal difficulties regarding visual access to data presented on the several CRT's. An additional light source was supplied by a ceiling-mounted system which consisted of electrified metal tracks on which moveable 40-footcandle, incandescent focusing lamps were seated. Each of these lamps illuminated approximately a 10-inch-diameter area, and was rheostatically controlled from each associated console. Philosophically, one could identify the fluorescent fixtures as a general ambient light source and the incandescent fixtures as dedicated operational position lighting.

One area of considerable concern was evinced from results gathered from part I of the Specialist Opinion Survey. Specifically, there was a marked increase in the incidence of eyestrain. The facility illumination levels were surveyed, and the range of the averages at different position are shown in table 21. The lighting levels fall below what is acceptable

TABLE 20. CHANGES IN FSS SPECIALIST ATTITUDE AS A RESULT OF EXPERIENCE

Atlanta Survey Data	Number of Favorable Changes With Means ≥4.0	Number of Unfavorable* Changes With Means ≥4.0
August 1975	3	1
October 1975	4	1
December 1975	6	0
July 1976	7	1

* This unfavorable change is in "Amount of Eyestrain."

TABLE 21. TYPICAL PREFLIGHT POSITION ILLUMINATION LEVELS

	Range (Footcandles)
Face of 14-inch CRT	0.5 - 1.0
Writing area under spotlight	20 - 45
Writing area, no spotlight coverage	0.8 - 2.0
Keyboards	0.7 - 1.4
Face of 23-inch group CRT Monitors	0.4 - 1.0

The above measurements were taken under normal daily operating conditions: Curtains closed, fluorescent fixtures operating in a very dim mode

for the types of tasks the AWANS specialists must perform. Results from part 2 of the Specialist Opinion Survey indicate a consensus that the lighting is inadequate for reading printed reference material. Verbal complaints from several of the specialists to the effect that they needed to have the optical prescriptions changed; e.g., one going to bifocals and another going from bifocals to trifocals, point to problems in accommodation under the low light levels.

With low light levels, the aperture of the pupil increases, reducing the depth of field of the eye and requiring more focusing action. The use of group CRT monitors at distances of 68-inches for the front row and 153-inches for the back row means that whenever the specialist looks from the CRT at his position (20-inch distant) to the group CRT monitors, a considerable amount of visual adjustment must take place. A number of the subject specialists are at or beyond the age when reduction in the ability to refocus the eyes from near objects to distant objects and back again becomes noticeable. The change from normal daylight, filtering through windows, to a relatively darkened working environment reportedly caused several individuals to seek medical attention. Additional visual problems could result from the specialists reading printed material under the illumination provided by a ceiling-mounted fixture which emits 40-footcandles of light and immediate reference to the position's CRT. Such problems are created by causing people to adapt rapidly from one light level to another. Ideally, the maximum variation in lighting should be within a range of 4 to 1; i.e., if the maximum illumination is 40-footcandles, the minimum should be no less than 10-footcandles.

SUMMARY OF RESULTS

1. The mean preflight weather briefing time was 2.62 minutes.

2. The mean preflight flight plan filing time was 2.17 minutes.

3. The mean preflight combined transaction time was 4.92 minutes.

4. The mean in-flight weather briefing time was 1.85 minutes.

5. The mean in-flight flight plan filing time was 2.97 minutes.

6. The mean in-flight flight plan activation time was 1.56 minutes.

7. The mean system data coordinator inbound Service-B transaction time was 1.22 minutes.

8. The mean system data coordinator incoming flight plan action time was 2.40 minutes.

9. Fully half of the daily workload at the system data coordinator position involved acknowledgment of messages received or transmitted.

CONCLUSIONS

From the results, the following conclusions are drawn:

1. The group CRT monitors were acceptable from the front row and marginally acceptable from the back row of preflight positions.

2. Although the manual data collection approach used in this study proved practicable, an automated monitoring and data collection system would be preferable on future systems destined for test and evalation.

3. Transaction times varied with the type of transaction, with the status of the group CRT monitors, and with the complexity of the transaction.

4. Local weather condition, console configuration, type of flight plan filed, and month of data collection produced no significant effect on transaction times. This is not to say that there was no effect of these variables, but that the effect was masked by other sources of variation.

5. The duration of flight service transactions is primarily dependent on the requirements of the pilot and the speed of acceptance and delivery of information by the specialist. Automation of the FSS has minimal impact on these factors. The use of AWANS has not reduced transaction times.

6. Both objective environmental measures and subjective measures indicate inadequate illumination. Typical levels were 1 footcandle except under the focused spot, which measured between 20 and 45 footcandles.

7. Noise levels were satisfactorily low.

8. The mean AWANS response time across 15 different system functions was 1.6 seconds for local terminals. This time fell within the response time specifications for the system. The response time for remote terminals was 5.2 seconds. This is far in excess of an acceptable value.

9. For part I of the Specialist Opinion Surveys, specialists at the Atlanta FSS had a highly favorable opinion of AWANS, whereas specialists at the satellite Macon facility had an unfavorable opinion. This unfavorable opinion was mainly due to the slower response times.

10. The only unfavorable opinion at the Atlanta FSS was that the "amount of eyestrain" increased after the implementation of AWANS.

11. Over a period of a year, the attitude of the AWANS specialists became increasingly more favorable.

12. Three CRT's at the specialist's console would obviate the need for the 23-inch group CRT monitors. A minimum of two displays is required.

13. The more different types of material that were accessed, the longer the transaction times became. If the transaction involved filing a flight plan, accessing weather text, accessing maps or radar, and referring to printed reference material, the mean transaction time was 7.02 minutes.

14. The verification of route coherence in AWANS is much more stringent than the adapted data bases of the National Airspace System (NAS) 9020 computer systems. Specifically, routes filed from an airport to intersect an airway in the area are acceptable in NAS, but this type of route filing will cause an error message from AWANS because the airport must be a published part of the airway structure. Consequently, flight plans entered through AWANS may indicate an error but are acceptable to the NAS 9020 system. This causes confusion and is a hindrance to the weather briefing function

because AWANS dictates that weather information may not be retrieved with a location or route that indicates an error. There was a gradually increasing lack of attention to those system messages which indicated an error in a filed route. The specialist, being aware of inconsistencies in location identifiers and route verification between the AWANS and the NAS, tended to disregard the message when in fact a valid error might have been present.

15. The availability of weather radar information was helpful to the preflight briefers and even more so to the In-flight and EFAS positions. This type of weather data allows a specialist to provide meaningful, current information to pilots. Specialist comments indicate a strong preference for the availability of radar information.

16. The presentation of digitized charts is convenient and useful. However, specialist opinions indicate a need for a more legible presentation. The graphics presented are digitized versions of NWS facsimile charts. This information, although useful in its present form, could be substantially improved with a source product specifically designed for presentation on a CRT. Charts are generated within the facility by hand when the digitized versions are unacceptable for use. This manual tracing of charts would be unnecessary if the digitized products were improved. Generally, specialist comments indicate the capability of graphics presentation is excellent although the images need improvement in clarity and legibility.

RECOMMENDATIONS

From the conclusions, the following recommendations are made:

1. Implement a computer-based monitoring, data collection, and reporting system such that the data required by studies such as the subject one could be obtained with a minimum of manual data collection.

2. Eliminate the group CRT monitors. The need for these monitors can be satisfied by the use of three CRT's at a position or, possibly, by the use of two CRT's and greatly improved methods of data access. There is no objective or subjective evidence that would support the retention of group CRT monitors.

3. Reduce the workload of the system data coordinator. Automated acknowledgments would be a step in the right direction.

4. If remote terminals are to be used, find a way to reduce the system response times to the acceptable level of the local terminals.

5. Increase the overall illumination levels and reduce the variation of the illumination level from one area to another.

6. Future automated facilities should be designed to insure that all displays can be used with uniform, comfortable lighting over all working surfaces except the display faces. Lighting levels on console shelves and keyboards should range between 20 and 30 footcandles.

7. The route verification feature should be routinely used by the specialist while still talking with a pilot to eliminate unnecessary error messages from NAS caused by incorrectly filed flight plans which cause additional, time-wasting handling. The AWANS and future automated systems should provide data base, field, and route verification features that will ensure congruence with NAS processing so as to allow weather information retrieval regardless of whether or not the departure airport is part of the airway structure.

8. At the System Data Coordinator position, there are as many as 335 messages in the system, some of which are written in language appropriate for a programer but not necessarily meaningful for the specialist who must use the system daily. Only through experience, would a specialist learn the meanings in some of these messages. However, it's recommended that system messages destined for the specialist should be unambiguous and in language appropriate to air traffic control. A reference book should be provided at the SDC position to define in greater detail the functional or operational meaning of these messages if suitable clarification cannot be provided by system capability.

9. System messages for the assistant chief are particularly cryptic and should be written in plain language. The abundant use of status messages throughout all phases of the operational program is an excellent feature. This capability should be included in any future system design.

10. There is an operational requirement to periodically review and delete obsolete weather advisories from the system. In addition, because of errors in preparation or transmission of NOTAM messages or because of brief system outages, cancellation messages may be missed, causing out-of-date NOTAM's to remain in the system. Correction of this problem requires a tedious manual comparison of the NOTAM data base with current NOTAM's or the initialization of the data base to eliminate any NOTAM's which are no longer current. Future systems should incorporate features to eliminate manual verification of the NOTAM or weather data base.

11. Provide a radar presentation of improved clarity which also has the capability of displaying digitized alphanumeric information to augment the graphic portrayed.

12. The modularity of components in some automated systems is more of a concept than a feature which has been implemented. However, in the case of AWANS, the ability to easily reconfigure the system has been used frequently with gratifying results. This is clearly attributable to the modularity characteristics inherent in the AWANS design. Considering the evidence of the need for flexibility in the utilization of AWANS hardware and software, one would logically conclude that there would be a high probability that follow-on systems will require similar modular design capabilities.